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Attorney's Ref: ABLUM/246/US
 Date: August 15, 2000

Sir:

Transmitted herewith for filing is the (X) utility () design patent application of
 Inventor(s): Mario C. Baldassari et al
 For: Multiple Stage Catalyst Bed Hydrocracking With Interstage Feeds

Enclosed are:

- (X) 1 sheet of () formal (X) informal drawings.
 () An assignment of the invention to _____
 () A certified copy of a _____ application.
 (X) An unsigned Inventors' Declaration and power of attorney.
 () A verified statement claiming small entity status.
 () A preliminary amendment.

The filing fee has been calculated as shown below:

- () design application for () small entity = \$155 () not small entity = \$310
 (X) utility application

	No. Filed	No. extra	Small Entity Rate	Fee	Not Small Entity Rate	Fee
Basic Fee				\$345	OR	\$690
Total Claims	8	- 20 = 0	x 9 =		OR x 18 =	
Indep. Claims	1	- 3 = 0	x 39 =		OR x 78 =	
Multiple Dependent Claims Presented			+ 130 =		OR + 260 =	
			TOTAL =		TOTAL =	\$690

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Multiple Stage Catalyst Bed Hydrocracking With Interstage Feeds

Background of the Invention

5 This invention relates to hydrocracking and more particularly to the hydrocracking of high boiling hydrocarbon materials to provide valuable lower boiling materials.

High boiling hydrocarbon materials derived from petroleum, coal or tar sand sources, usually petroleum residuum or solvent refined coal, are typically hydrocracked in ebullated (expanded) bed or fixed bed catalytic reactors in order to produce more valuable lower boiling materials such as transportation fuels or lubricating oils. In order to obtain a desired degree of hydrogenation for hydrocracking and hydrotreating, there are typically several reactors in series. As an example, see U.S. Patent 4,411,768. In these systems, the hydrogen partial pressure declines due to the consumption of hydrogen and the production of light hydrocarbon vapors from the cracking of the heavier liquid fractions and the concentration of lighter and typically more paraffinic liquid components increases with increasing residuum conversion. This reduction in hydrogen partial pressure and increase in concentration of lighter more paraffinic constituents results in an increase in sediment formation, limiting the residuum conversion level which can be attained based on either product quality or reactor operability constraints.

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Summary of the Invention

The object of the present invention is to reduce the sediment formation and increase the conversion levels for a high boiling hydrocarbon feedstock in a catalyst bed hydrogenation process with a plurality of reactors in series. The invention involves the introduction of

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an interstage feed between the series of reactors comprising an aromatic solvent and/or a portion of the high boiling hydrocarbon feedstock.

5 **Brief Description of the Drawing**

The drawing is a process flow diagram illustrating the process of the present invention.

Detailed Description of the Invention

10 The present invention relates to a process employing multiple stage catalyst bed hydrocracking and using a plurality of catalyst bed reactors in series. Although the invention is applicable to either ebullating bed reactors or fixed bed reactors, the invention will be described in detail in reference to ebullating bed reactors.

15 Referring to the drawing, a heavy, high boiling feed 10 of feedstock material 11 is heated in feed heater 12 to the temperature required for the catalytic hydrogenation reaction, usually in the range from 650°F to 725°F. The heated feed 14, primarily components boiling above 975°F, is combined in the feed mixer 16 with a hydrogen-rich stream 18 which has been heated in the hydrogen heater 20 to a temperature typically ranging from 650°F to 1025°F. This hydrogen-rich stream 18 represents a portion of the total hydrogen-rich gas stream 22 composed of purified recycle gas or make-up hydrogen or a combination of both. The other portion 24 of the recycle gas stream
20
25 22, which is also heated at 20, is fed to the second ebullating catalyst bed reactor as will be described later.

The heated mixture 26 of hydrogen and feed material is introduced into the bottom of the ebullating catalyst bed reactor 28. Such reactors containing an expanded bed of hydrogenation catalyst are

well known in the art. The hydrogenation catalysts suitable for hydrocracking and hydrotreating heavy, high boiling hydrocarbons are also well known and include but are not limited to nickel-molybdate, cobalt-molybdate and cobalt-nickel-molybdate with these catalyst materials typically carried on supports such as alumina. A typical operating temperature for the reactor 28 is in the range of 750 to 840°F.

The liquid portion of stream 30 from reactor 28 contains the partially converted materials having a boiling range from less than 350°F to over 975°F. The nature of this stream 30 is typically as follows:

	<u>Fraction</u>	<u>Boiling Range</u>	<u>Wt. %</u>
	Unconverted heavy oil	975°F +	35-70%
	Vacuum gas oil	650-975°F	20-60%
	Atmospheric gas oil	350-650°F	5-20%
15	Naphtha	350°F-	1- 5%

This stream 30 is mixed at 42 with hydrogen-rich gas stream 44, a portion 24 of which has been heated in 20, typically to 650°F to 1025°F, with the remainder 38 supplied at a temperature of between 200°F to 650°F. Also mixed with the stream 30 in accordance with the present invention is an interstage feed 32 which is composed of a portion 34 of the high boiling feedstock material 11 and/or an aromatic solvent 36 such as cat cracker light cycle oil, heavy cycle oil or decant oil. The resulting mixture 50 is then sent to the second ebullating catalyst bed reactor 46.

Introducing this stream 32 directly into the second reactor 46 which operates at the highest severity and residuum conversion level, acts to limit the sediment formation compared with the usual commercial practice where all of the aromatic solvent is introduced into the first reactor. As a result, for a given quantity of aromatic solvent,

the preferential introduction of this solvent into the second reactor will extend the residuum conversion level at which the unit can be operated. Also, the injection of a portion of the heavy high boiling feed directly into the second reactor acts to reduce sediment formation, allowing
5 residuum conversion levels to be increased by increasing the resin to asphaltene concentration ratio in the liquid phase in the second reactor.

The introduction of 5 to 10 volume% (about the same value in weight %) of an aromatic solvent (based on the weight of the feed), such as cat cracker light cycle oil, heavy cycle oil or decant oil, into the
10 second reactor reduces the sediment formation, as measured by SMS-2696, by 0.1 to 0.2 wt.% for a given level of residuum conversion. As a result, for a given unconverted residue product sediment specification and/or reactor heavy oil sediment limit, it has been determined that residuum conversion can be increased 3 to 5%. Alternatively, for given
15 unconverted product sediment and residuum conversion levels, the catalyst replacement rate can be reduced 10 to 20%.

Instead of or in addition to the introduction of the aromatic solvent, 10 to 20% of the heavy high boiling residuum feedstock material may be fed directly into the second reactor. This also acts to
20 reduce sediment formation by increasing the resin to asphaltene concentration ratio in the liquid phase in this reactor. As a result, residuum conversion levels can be increased an additional 2 to 3%. Further, the introduction of unconverted resin acts to redissolve sediment which has been formed as a result of hydrocracking the
25 residuum in the first reactor.

The feed 50 to the second reactor 46 undergoes further hydrocracking in this reactor producing the effluent 52 which is fed to the high pressure separator 54 along with quench oil 56, if required, to reduce the temperature and coking tendency of the liquid. Depending

on the application, the vapor 58 from the separator 54 may then be fed to a wash tower 60 where it is contacted with wash oil 62, typically having a boiling range of 500°F to 975°F. The wash oil 62 could either be derived internally from the process or supplied externally from other refinery process units. The resulting vapor product 64 from the wash tower 60 is typically cooled 30°F to 70°F by contact with the wash oil 62. As a result, entrainment of residuum plus the content of residuum boiling fractions (975°F+), in equilibrium with the liquid phase, in stream 64 is significantly reduced. The vapor product from the wash tower can then either be cooled and purified and recycled back to reactors 28 and 46 or alternatively first be processed through in-line hydrotreating and/or hydrocracking reactors along with other internally derived intermediate liquid products or externally supplied distillate boiling range feeds. The liquid 66 from the wash tower 60 composed of remaining unvaporized constituents of the wash oil 62 plus residuum removed from stream 58 is combined with the liquid 55 from separator 54 containing unconverted residuum plus lighter boiling fractions resulting from conversion of the residuum in reactors 28 and 46. This combined heavy oil liquid stream 67 is then flashed in the heavy oil flash drum 68. The resulting flashed vapor 69 is then cooled by heat exchange. The partially cooled stream is then separated in 70. The separated vapor 71 is then further cooled after which it undergoes further separation in 72 producing a cooled hydrogen-rich vapor 74 which is typically recycled after further purification. The hydrocarbon liquids recovered from cooling and separating the vapor streams are collected in the flash drums 70 and 72. The resulting liquid products, 78 and 80 plus the flashed heavy oil 76, as well as liquid recovered from the vapor 64 are typically routed to a fractionation system for separation and further processing.

Claims:

1. A method of hydrocracking a high boiling hydrocarbon feedstock comprising the steps of:

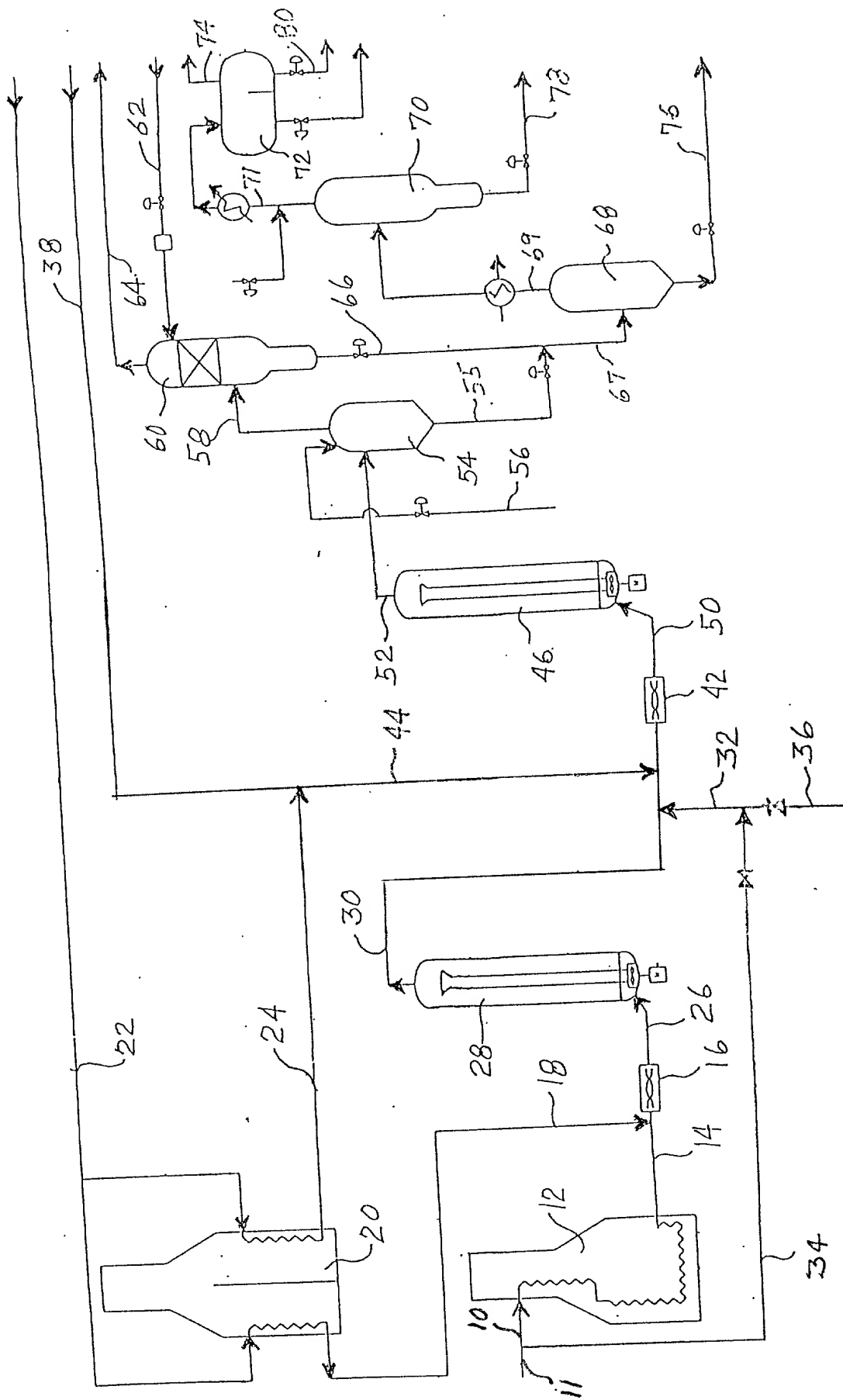
- 5 a. partially hydrocracking said feedstock comprising contacting said feedstock with hydrogen in a first reactor containing a bed of catalyst particles thereby forming an effluent mixture of C₄- light ends and lower boiling hydrocarbons and higher boiling hydrocarbons;
- 10 b. blending a liquid selected from an aromatic solvent and feedstock material and combinations thereof with said effluent mixture;
- 15 c. further hydrocracking said blended effluent mixture comprising contacting said blended effluent mixture with hydrogen in a second reactor containing a bed of catalyst particles thereby forming a further effluent stream containing additional lower boiling hydrocarbons and the remaining unconverted higher boiling hydrocarbons; and
- 20 d. separating said further effluent stream into a plurality of hydrocarbon product streams.
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2. A method as recited in claim 1 wherein said lower boiling hydrocarbons boil below about 650°F and said higher boiling hydrocarbons boil above about 650°F.

3. A method of hydrocracking as recited in claim 1 wherein said selected liquid comprises from 5 to 10 volume % aromatic solvent based on the volume of feedstock.
- 5 4. A method of hydrocracking as recited in claim 1 wherein said selected liquid comprises from 10 to 20 volume % of said feedstock material based on the volume of said feedstock.
- 10 5. A method as recited in claim 1 wherein said selected liquid comprises from 5 to 10 volume % aromatic solvent based on the weight of feedstock and from 10 to 20 volume % of said feedstock material based on the weight of said feedstock.
- 15 6. A method as recited in claim 1 wherein said first and second reactors are ebullating bed reactors.
7. A method as recited in claim 1 wherein said first and second reactors are fixed bed reactors.
- 20 8. A method as recited in claim 1 wherein each of said first and second reactors are selected from fixed bed and ebullating bed reactors.

Abstract of the Disclosure

High boiling hydrocarbon materials are hydrocracked in a multiple stage process having ebullating or fixed catalyst bed hydrogenation reactor stages in series. Between the hydrogenation reactors is an
5 interstage feed of an aromatic solvent and/or a portion of the high boiling hydrocarbon feedstock.



DECLARATION FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Multiple Stage Catalyst Bed Hydrocracking With Interstage Feeds

the specification of which (X) is attached hereto.

() was filed on _____ as Application Serial
No. _____ with amendments through _____.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, Section 1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

Priority Claimed

_____ Number	_____ Country	_____ Day/Month/Year Filed	() Yes	() No
_____ Number	_____ Country	_____ Day/Month/Year Filed	() Yes	() No

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section

112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, Section 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

Serial No.	Filing Date	Status (patented, pending)
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Serial No.	Filing Date	Status (patented, pending)
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

I hereby appoint Guy D. Yale, Reg. No. 29,125; L. James Ristas, Reg. No. 28,663; Richard H. Berneike, Reg. No. 21,126; Clifford P. Kelly, Reg. No. 35,213; James E. Piotrowski, Reg. No. 43,860; Thomas J. Menard, Reg. No. 42,877; Arthur E. Fournier, Jr., Reg. No. 22,816 and Russell W. Warnock, Reg. No. 32,860 or any of them, as my attorneys to prosecute this application with full power of substitution and revocation and to transact all business in the Patent and Trademark Office in connection therewith. All correspondence should be directed to:

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